PATENT ABSTRACTS OF JAPAN

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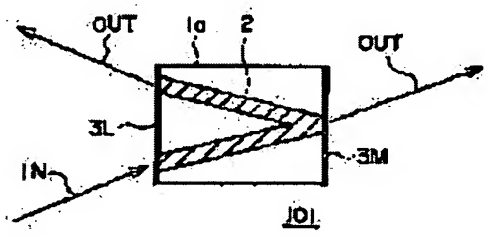
(54) SEMICONDUCTOR OPTICAL AMPLIFIER

(57)Abstract:
PROBLEM TO BE SOLVED: To conduct a branch of light and an amplification of the light by a single semiconductor optical amplifier to miniaturize a device and at the same time, to enlarge a gain region per single semiconductor optical amplifier to contrive an increase in the output of the device.
SOLUTION: Input light IN entered into a semiconductor optical amplifier 101 from the outside is amplified at a gain region 2 to reach the right end of an amplifier body 1a. One part of the light is transmitted a coating layer 3M and is turned into output light OUT, the which is emitted to the outside of the amplifier 101, but one part of the light OUT is reflected to pass through a gain region 2 of a path different from that of the region 2, where the light IN is subjected to amplification to the left end of the body 1a, and is amplified.



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CLAIMS

[Claim(s)]
[Claim 1] the semi-conductor optical amplifier characterize by to be the semi-conductor optical amplifier which established the semiconductor laser structure had the gain field which give gain from the outside to light , and for the coating layer which have a desired reflection factor to be prepare in the external surface of the body of a semi-conductor optical amplifier , to make a part penetrate while reflect the light inputted and amplified from the outside inside in the above-mentioned coating layer of the internal end face of the above-mentioned body of a semi-conductor optical amplifier , and to make outgoing radiation carry out outside .
[Claim 2] The semi-conductor optical amplifier according to claim 1 characterized by the above-mentioned gain field consisting of a thing of the V character mold which goes back and forth between the both-ends sides of the above-mentioned body of a semi-conductor optical amplifier.
[Claim 3] The semi-conductor optical amplifier according to claim 1 characterized by the above-mentioned gain field consisting of a thing of the winding path mold which carries out the multiple-times round trip of between the both-ends sides of the above-mentioned body of a semi-conductor optical amplifier.
[Claim 4] The semi-conductor optical amplifier according to claim 3 characterized by carrying out outgoing radiation of the light from both-sides side of the both-ends side of the above-mentioned body of a semi-conductor optical amplifier.
[Claim 5] The semi-conductor optical amplifier according to claim 3 characterized by carrying out outgoing radiation of the light from the one side side of the both-ends side of the above-mentioned body of a semi-conductor optical amplifier.
[Claim 6] The semi-conductor optical amplifier according to claim 1 characterized by for the above-mentioned body of a semi-conductor optical amplifier consisting of a rectangle-like thing, and the above-mentioned gain field consisting of a thing of the shape of a rectangle reflected in order in the side where the above-mentioned body of a semi-conductor optical amplifier adjoins.
[Claim 7] The semi-conductor optical amplifier according to claim 6 characterized by carrying out outgoing radiation of the light from a field three of the above-mentioned bodies of a semi-conductor optical amplifier side.
[Claim 8] The semi-conductor optical amplifier according to claim 6 characterized by carrying out outgoing radiation of the light from a field four of the above-mentioned bodies of a semi-conductor optical amplifier side.
[Claim 9] The semi-conductor optical amplifier according to claim 1 characterized by having further the temperature adjustment device which the above-mentioned reflection and **** are performed in two or more parts of the above-mentioned semi-conductor optical amplifier, respectively, and performs the temperature control of the above-mentioned semi-conductor optical amplifier in order to arrange the phase of the light by which outgoing radiation was carried out to the above-mentioned semi-conductor optical amplifier exterior.
[Claim 10] The semi-conductor optical amplifier according to claim 1 characterized by being formed so that it may have the tee by which the above-mentioned body of a semi-conductor optical amplifier and the coating layer of the external surface reflect light in an inside 2-way and the above-mentioned gain field may branch according to this.
[Claim 11] The semi-conductor optical amplifier according to claim 10 characterized by the above-

mentioned tee consisting of a convex type tee projected in the V character mold inside.
[Claim 12] The semi-conductor optical amplifier according to claim 10 characterized by the above-mentioned tee consisting of a concave tee projected in the V character mold outside.
[Claim 13] The semi-conductor optical amplifier according to claim 1 characterized by for the end face of the above-mentioned semi-conductor optical amplifier having the field where reflection factors differ, respectively, reflecting a part of amplified light, and penetrating a part.
[Claim 14] The semi-conductor optical amplifier according to claim 13 characterized by coming to prepare two or more coating layers which have a reflection factor which is different on the external surface of the above-mentioned body of a semi-conductor optical amplifier.
[Claim 15] The semi-conductor optical amplifier according to claim 13 characterized by becoming by the coating layer prepared in the external surface of the above-mentioned body of a semi-conductor optical amplifier, and the mirror partially prepared in the outside.
[Claim 16] The semi-conductor optical amplifier according to claim 1 to 15 characterized by having made the above-mentioned gain field into the shape of a taper which spreads along the travelling direction of light, and fixing gain along the above-mentioned gain field.
[Claim 17] The semi-conductor optical amplifier according to claim 1 characterized by preparing combining the semiconductor laser component as a generation source of the light which carries out incidence to the above-mentioned semi-conductor optical amplifier on a single component.
[Claim 18] the oscillation section which generates light, and the amplifier which gives and amplifies gain in the light generated by this -- since -- the semi-conductor optical amplifier characterized by becoming.
[Claim 19] The semi-conductor optical amplifier according to claim 18 with which the above-mentioned oscillation section which prepares a grating in a part of gain field, and sends light to a desired location, and the above-mentioned amplifier which established the gain field in the travelling direction of the sent light are characterized by being formed as a single component.
[Claim 20] The semi-conductor optical amplifier according to claim 18 characterized by carrying these which consist of an oscillation component which prepared the grating so that the above-mentioned oscillation section may carry out outgoing radiation of the light to a necessary location, and consist of an amplifier with the gain field whose above-mentioned amplifier corresponded with the location of the light by which outgoing radiation was carried out on one base.
[Claim 21] The semi-conductor optical amplifier according to claim 20 characterized by having inserted the transparent insulator optically and attaching the electric partition between both sides between the above-mentioned oscillation component and an amplifier.
[Claim 22] The semi-conductor optical amplifier with which a reflection factor is characterized by preparing the coating layer near 0% at the side which carries out incidence of the light so that the incidence of the light can be carried out to the gain field in which the grating of a field luminescence semiconductor laser component was formed from the exterior.
[Claim 23] The semi-conductor optical amplifier according to claim 22 characterized by adjusting the die length of the field which attaches the grating of the gain field of the above-mentioned field luminescence semiconductor laser component, and adjusting the luminous intensity outputted.
[Claim 24] The semi-conductor optical amplifier according to claim 22 or 23 characterized by preparing further the reflective section which reflects the light which passed through the above-mentioned gain field in the same direction as the outgoing radiation light deflected by the above-mentioned grating.

[Translation done.]

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the semi-conductor optical amplifier of the progressive wave mold used mainly as optical communication, optical application measurement, the light source for optical information processing, and the light source for solid-state-laser excitation.
[0002]
[Description of the Prior Art] drawing 20 be the sectional view show the configuration of the semi-conductor optical amplifier which have the general conventional semiconductor laser structure , and the gain field where a semi-conductor optical amplifier and 1 give the body of a semi-conductor optical amplifier (it consider as the body of amplifier below) from the outside to the input light IN , and , as for 2 , 100 give gain , the coating layer which make small the reflection factor by which coating of the 3L be carry out to the external surface of the body 1 of amplifier as much as possible , and OUT be the output light by which outgoing radiation be carry out to the exterior of the semi-conductor optical amplifier 100 in drawing .
[0003] Next, actuation is explained. If the input light IN from the outside passes through the gain field 2 within the body 1 of amplifier, the light from the outside will acquire gain and will be amplified.
[0004]
[Problem(s) to be Solved by the Invention] In the conventional semi-conductor optical amplifier constituted as mentioned above, in the case of the communication link which light is branched and spreads the same information in two or more circuits since it was only amplifying etc., since magnification and branching of light were performed with the respectively separate component, the whole equipment was large. Moreover, when light by which wavelength control was carried out was high-power-ized using a semi-conductor optical amplifier, there was a limit in enlarging one gain field of a single semi-conductor optical amplifier, and the limitation was in the output obtained.
[0005] It aims at obtaining the semi-conductor optical amplifier which can generate high power by this invention having been made in order to cancel the above technical problems, and it being able to perform both branching of light, and magnification, and making large all the gain fields of a single semi-conductor optical amplifier.
[0006]
[Means for Solving the Problem] An example is taken by the above-mentioned purpose. Invention of the 1st of this invention It is the semi-conductor optical amplifier which established the semiconductor laser structure of having the gain field which gives gain from the outside to light. While reflecting the light which the coating layer which has a desired reflection factor was prepared in the external surface of the body of a semi-conductor optical amplifier, and was inputted and amplified from the outside inside in the above-mentioned coating layer of the internal end face of the above-mentioned body of a semi-conductor optical amplifier It is in the semi-conductor optical amplifier characterized by making a part penetrate and making outgoing radiation carry out outside.
[0007] The semi-conductor optical amplifier according to claim 1 characterized by the above-mentioned gain field consisting of a thing of the V character mold which goes back and forth between the both-ends sides of the above-mentioned body of a semi-conductor optical amplifier has invention of the 2nd of this invention.

[0008] The semi-conductor optical amplifier according to claim 1 characterized by the above-mentioned gain field consisting of a thing of the winding path mold which carries out the multiple-times round trip of between the both-ends sides of the above-mentioned body of a semi-conductor optical amplifier has invention of the 3rd of this invention.
[0009] The semi-conductor optical amplifier according to claim 3 characterized by carrying out outgoing radiation of the light from both-sides side of the both-ends side of the above-mentioned body of a semi-conductor optical amplifier has invention of the 4th of this invention.
[0010] The semi-conductor optical amplifier according to claim 3 characterized by carrying out outgoing radiation of the light from the one side side of the both-ends side of the above-mentioned body of a semi-conductor optical amplifier has invention of the 5th of this invention.
[0011] The semi-conductor optical amplifier according to claim 1 characterized by for the above-mentioned body of a semi-conductor optical amplifier consisting of a rectangle-like thing, and the above-mentioned gain field consisting of a thing of the shape of a rectangle reflected in order in the side where the above-mentioned body of a semi-conductor optical amplifier adjoins has invention of the 6th of this invention.
[0012] The semi-conductor optical amplifier according to claim 6 characterized by carrying out outgoing radiation of the light from a field three of the above-mentioned bodies of a semi-conductor optical amplifier side has invention of the 7th of this invention.
[0013] The semi-conductor optical amplifier according to claim 6 characterized by carrying out outgoing radiation of the light from a field four of the above-mentioned bodies of a semi-conductor optical amplifier side has invention of the 8th of this invention.
[0014] The above-mentioned reflection and **** are performed in two or more parts of the above-mentioned semi-conductor optical amplifier, respectively, and in order to arrange the phase of the light by which outgoing radiation was carried out to the above-mentioned semi-conductor optical amplifier exterior, the semi-conductor optical amplifier according to claim 1 characterized by having further the temperature adjustment device which performs the temperature control of the above-mentioned semi-conductor optical amplifier has invention of the 9th of this invention.
[0015] Invention of the 10th of this invention has the tee by which the above-mentioned body of a semi-conductor optical amplifier and the coating layer of that external surface reflect light in an inside 2-way, and is in the semi-conductor optical amplifier according to claim 1 characterized by being formed so that the above-mentioned gain field may branch according to this.
[0016] Invention of the 11th of this invention has the above-mentioned tee in the semi-conductor optical amplifier according to claim 10 characterized by consisting of a convex type tee projected in the V character mold inside.
[0017] Invention of the 12th of this invention has the above-mentioned tee in the semi-conductor optical amplifier according to claim 10 characterized by consisting of a concave tee projected in the V character mold outside.
[0018] Invention of the 13th of this invention has the end face of the above-mentioned semi-conductor optical amplifier in the semi-conductor optical amplifier according to claim 1 characterized by having the field where reflection factors differ, respectively, reflecting a part of amplified light, and penetrating a part.
[0019] The semi-conductor optical amplifier according to claim 13 characterized by coming to prepare two or more coating layers which have a reflection factor which is different on the external surface of the above-mentioned body of a semi-conductor optical amplifier has invention of the 14th of this invention.
[0020] The semi-conductor optical amplifier according to claim 13 characterized by becoming by the coating layer prepared in the external surface of the above-mentioned body of a semi-conductor optical amplifier and the mirror partially prepared in that outside has invention of the 15th of this invention.
[0021] The semi-conductor optical amplifier according to claim 1 to 15 characterized by having made the above-mentioned gain field into the shape of a taper which spreads along the travelling direction of light, and fixing gain along the above-mentioned gain field has invention of the 16th of this invention.
[0022] it is that of this invention -- the semi-conductor optical amplifier according to claim 1

characterized by preparing combining the semiconductor laser component as a generation source of the light which carries out incidence to the above-mentioned semi-conductor optical amplifier on a single component has invention of 17.
[0023] the oscillation section in which invention of the 18th of this invention generates light, and the amplifier which gives gain at the light with which it was generated by this, and is amplified -- since -- it is in the semi-conductor optical amplifier characterized by becoming.
[0024] Invention of the 19th of this invention has the above-mentioned oscillation section which prepares a grating in a part of gain field, and sends light to a desired location, and the above-mentioned amplifier which established the gain field in the travelling direction of the sent light in the semi-conductor optical amplifier according to claim 18 characterized by being formed as a single component.
[0025] The semi-conductor optical amplifier according to claim 18 characterized by carrying these which consist of an oscillation component which prepared the grating so that the above-mentioned oscillation section may carry out outgoing radiation of the light to a necessary location, and consist of an amplifier with the gain field whose above-mentioned amplifier corresponded with the location of that light by which outgoing radiation was carried out on one base has invention of the 20th of this invention.
[0026] Invention of the 21st of this invention sandwiches a transparent insulator optically between the above-mentioned oscillation component and an amplifier, and is in the semi-conductor optical amplifier according to claim 20 characterized by attaching the electric partition between both sides.
[0027] Invention of the 22nd of this invention has a reflection factor in the semi-conductor optical amplifier characterized by preparing the coating layer near 0% at the side which carries out incidence of the light so that the incidence of the light can be carried out to the gain field in which the grating of a field luminescence semiconductor laser component was formed from the exterior.
[0028] The semi-conductor optical amplifier according to claim 22 characterized by adjusting the die length of the field which attaches the grating of the gain field of the above-mentioned field luminescence semiconductor laser component, and adjusting the luminous intensity outputted has invention of the 23rd of this invention.
[0029] A semi-conductor optical amplifier given in either of claims 22 and 23 characterized by preparing further the reflective section which reflects the light which passed through the above-mentioned gain field in the same direction as the outgoing radiation light deflected by the above-mentioned grating has invention of the 24th of this invention.
[0030]
[Embodiment of the Invention] Hereafter, the gestalt of implementation of this invention is explained.
Gestalt 1. drawing 1 of operation is the sectional view showing roughly the configuration of the semi-conductor optical amplifier by the gestalt 1 of implementation of this invention. In drawing, the gain field of the V character mold with which a semi-conductor optical amplifier and 1a give the body of a semi-conductor optical amplifier (it considers as the body of amplifier below) from the outside to the input light IN, and, as for 2, 101 gives gain, a coating layer with the reflection factor near [3L] 0% which makes the light prepared in the end face of body of amplifier 1a penetrate about 100%, and 3M are coating layers with the reflection factor optimized from the amplification factor.
[0031] Next, if intermediary ****** is carried out at actuation, the input light IN from the outside by which incidence was carried out from the left-hand side of drawing 1 at the semi-conductor optical amplifier 101 will be amplified in the gain field 2, and will arrive at the right end of body of amplifier 1a. Although a part of light turns into the output light OUT which penetrates coating layer 3M and carries out outgoing radiation to the exterior of the semi-conductor optical amplifier 101, it having been reflected and having received magnification at the left end of body of amplifier 1a passes through the gain field 2 of alternative pathway, and a part is amplified.
[0032] And the magnification light which arrived at the left end of body of amplifier 1a penetrates coating layer 3L, and outgoing radiation is carried out in the exterior of the semi-conductor optical amplifier 101. Consequently, since outgoing radiation of the magnification light is carried out from the right-and-left edge of the semi-conductor optical amplifier 101, it means performing

magnification and branching of the input light IN from the outside to coincidence. In addition, if the amplification factor in the gain field 2 and the reflection factor in a coating layer are chosen suitably, the output light OUT of the same magnitude can also be obtained at the right-and-left edge of the semi-conductor optical amplifier 101.

[0033] Gestalt 2. drawing 2 of operation is the sectional view showing roughly the configuration of the semi-conductor optical amplifier by the gestalt 2 of implementation of this invention. In drawing, the gain field of the winding path mold with which a semi-conductor optical amplifier and 1b give the body of amplifier from the outside to the input light IN, and, as for 2, 102 gives gain, a coating layer with the reflection factor near [3L] 0% which makes light penetrate about 100%, and 3M are coating layers with the reflection factor optimized from the amplification factor.

[0034] Although the principle of operation is the same as the gestalt 1 of the above-mentioned implementation, with the gestalt 2 of operation, the gain field 2 is the thing of the winding path mold which carries out the multiple-times round trip of between the both-ends sides of body of amplifier 1b, and branching of light is performed two or more times. Moreover, outgoing radiation of the output light OUT is carried out from right-and-left one end of the semi-conductor optical amplifier 102. Thereby more much output light OUT can be obtained.

[0035] Gestalt 3. drawing 3 of operation is the sectional view showing roughly the configuration of the semi-conductor optical amplifier by the gestalt 3 of implementation of this invention. In drawing, the gain field of the winding path mold with which a semi-conductor optical amplifier and 1c give the body of amplifier from the outside to the input light IN, and, as for 2, 103 gives gain, a coating layer with the reflection factor near [3L] 0% which makes light penetrate about 100%, a coating layer with the reflection factor by which 3M were optimized from the amplification factor, and 3H are coating layers whose reflection factors are 100%.

[0036] With the gestalt of this operation, by preparing coating layer 3H whose a reflection factor is 100% in the end face of one side of body of amplifier 1c, it was made to carry out outgoing radiation of the output light OUT from one side of the semi-conductor optical amplifier 103, and the direction of outgoing radiation of the output light OUT is restricted.

[0037] Gestalt 4. drawing 4 of operation is the sectional view showing roughly the configuration of the semi-conductor optical amplifier by the gestalt 4 of implementation of this invention. In drawing, the rectangle-like gain field where a semi-conductor optical amplifier and 1d of rectangle-like bodies of amplifier are given to the input light IN from the outside, and, as for 2, 104 gives gain, a coating layer with the reflection factor near [3L] 0% which makes light penetrate about 100%, and 3M are coating layers with the reflection factor optimized from the amplification factor.

[0038] the gain field 2 which give gain from the outside to light be use as the character type of KO so that it may reflect in order in the adjoining side of 1d of bodies of amplifier, reflection and outgoing radiation be perform and not only the both sides end face of the semi-conductor optical amplifier 104 but one side of the side face which extend in the direction which intersect perpendicularly with these can make the outgoing radiation of the amplified output light OUT carry out in the three directions in the semi-conductor optical amplifier 104 of the gestalt of this operation.

[0039] Gestalt 5. drawing 5 of operation is the sectional view showing roughly the configuration of the semi-conductor optical amplifier by the gestalt 5 of implementation of this invention. In drawing, the rectangle-like gain field where a semi-conductor optical amplifier and 1e give rectangle-like the body of amplifier from the outside to the input light IN, and, as for 2, 105 gives gain, a coating layer with the reflection factor near [3L] 0% which makes light penetrate about 100%, and 3M are coating layers with the reflection factor optimized from the amplification factor.

[0040] The gain field 2 which give gain from the outside to light be use as the character type of RO so that it may reflect in order in the side where body of amplifier 1e adjoin , and the outgoing radiation of the output light OUT which reflection and outgoing radiation be performed and be amplified , respectively not only on the both sides end face of the semi-conductor optical amplifier 105 but on the side face of the both sides of this can be make to carry out in the four directions in the semi-conductor optical amplifier 105 of the gestalt of this operation .

[0041] Gestalt 6. drawing 6 of operation is the sectional view showing roughly the configuration of the semi-conductor optical amplifier by the gestalt 6 of implementation of this invention. The semi-conductor optical amplifier 106 is equipped with the heat regulator 4 which constitutes a temperature

adjustment device in the amplifier of drawing 3 in drawing. With the gestalt of this operation, the phase of the output light OUT which carries out outgoing radiation from each part can be doubled by ****** which adds a heat regulator 4 and adjusts the temperature of body of amplifier 1c.

[0042] In addition, although what is necessary is just to constitute a heat regulator 4 from a heater, it is good to constitute from a desirable semiconductor device with a high temperature precision called a PERUCHIE cooler, for example. Moreover, the gestalt of this operation can be applied to all the amplifier that carries out outgoing radiation not only of the amplifier of drawing 3 but two or more output light, and the same effectiveness is acquired.

[0043] Gestalt 7. drawing 7 of operation is the sectional view showing roughly the configuration of the semi-conductor optical amplifier by the gestalt 7 of implementation of this invention. In drawing, the gain field of the arrow-head mold with which a semi-conductor optical amplifier and 1f of bodies of amplifier are given to the input light IN from the outside, and, as for 2, 107 gives gain, a coating layer with the reflection factor near [3L] 0% which makes light penetrate about 100%, a coating layer with the reflection factor by which 3M were optimized from the amplification factor, and 5a are convex type tees which branch the amplified light to a both-sides 2-way. The end face of 1f of bodies of an amplifier and coating layer 3M project inside the semi-conductor optical amplifier 107 at a V character mold, and, as for this convex type tee 5a, are formed, respectively.

[0044] Although the principle of operation is the same as the gestalt of each above-mentioned operation, especially, it is reflection in convex type tee 5a of the end face of 1f of bodies of amplifier, and light can be branched to a 2-way at once.

[0045] Gestalt 8. drawing 8 of operation is the sectional view showing roughly the configuration of the semi-conductor optical amplifier by the gestalt 8 of implementation of this invention. In drawing, the gain field of the arrow-head mold with which a semi-conductor optical amplifier and 1g of bodies of amplifier are given to the input light IN from the outside, and, as for 2, 108 gives gain, a coating layer with the reflection factor near [3L] 0% which makes light penetrate about 100%, a coating layer with the reflection factor by which 3M were optimized from the amplification factor, and 5b are concave tees which branch the amplified light to a both-sides 2-way. The end face of 1g of bodies of an amplifier and coating layer 3M project on the outside of the semi-conductor optical amplifier 108 at a V character mold, and, as for this concave tee 5b, are formed, respectively.

[0046] If it differs from the gestalt 7 of operation, a tee is the point which consists of concave tee 5b projected in the V character mold on the outside of the semi-conductor optical amplifier 108, and that of ** is the same as that of the gestalt 7 of operation about other actuation and effectiveness.

[0047] Gestalt 9. drawing 9 of operation is the sectional view showing roughly the configuration of the semi-conductor optical amplifier by the gestalt 9 of implementation of this invention. In drawing, 109 with the arrow-head mold with which a semi-conductor optical amplifier and 1h of bodies of amplifier are given to the input light IN from the outside, and 2 gives gain And the gain field of the shape of a taper which spreads along the travelling direction of light, A coating layer with the reflection factor near [3L] 0% which makes light penetrate about 100%, a coating layer with the reflection factor by which 3M were optimized from the amplification factor, and 5a are convex type tees which branch the amplified light to a both-sides 2-way.

[0048] Although the semi-conductor optical amplifier 109 of the gestalt of this operation is fundamentally the same as the thing of the gestalt 7 of operation, by making the gain field 2 into the shape of a taper, he is trying for gain to always become fixed and a thereby more large amplification factor is obtained.

[0049] A propagation beam, i.e., light, spreads with advance. Since gain changes with luminous intensities, in order to acquire fixed gain, it needs to make the size of a gain field, and the size of light in agreement. If luminous intensity becomes strong, gain will fall according to a saturation phenomenon. Therefore, in order to enlarge an amplification factor, it becomes a good approach to make the gestalt of a gain field and light in agreement. So, the gain field 2 was made into the shape of a taper with the gestalt of this operation.

[0050] In addition, making the gain field 2 into the shape of a taper which spreads along the travelling direction of light can be applied also in the gestalt of other operations, without being limited to the gestalt of this operation, and the same effectiveness is acquired.

[0051] Gestalt 10. drawing 10 of operation is the sectional view showing roughly the configuration

of the semi-conductor optical amplifier by the gestalt 10 of implementation of this invention. In drawing, the gain field of the shape of a taper which 110 is the V character mold with which a semi-conductor optical amplifier and 1i give the body of amplifier from the outside to the input light IN, and 2 gives gain, and spreads along the travelling direction of light, a coating layer with the reflection factor near [3L] 0% which makes light penetrate about 100%, and 3H are coating layers whose reflection factors are 100%.

[0052] In the semi-conductor optical amplifier 110 of the gestalt of this operation, the input light OUT from the outside which carried out incidence is amplified in the gain field 2, and arrives at the right end of body of amplifier 1i. Although a part of light penetrates coating layer 3L near 0% and a reflection factor carries out outgoing radiation to the exterior of the semi-conductor optical amplifier 110, a reflection factor is reflected by coating layer 3H which are 100%, and a part passes through the gain field 2 of a path different from the above-mentioned at the left end of body of amplifier 1i, and is amplified. The magnitude of outgoing radiation opening becomes large so that waveguide becomes long, when amplifying using taper-like waveguide 2, i.e., a gain field, but if a part of light is started like this invention, waveguide cannot become [magnitude of outgoing radiation opening] large too much.

[0053] Gestalt 11. drawing 11 of operation is the sectional view showing roughly the configuration of the semi-conductor optical amplifier by the gestalt 11 of implementation of this invention. In drawing, the gain field of the shape of a taper which 111 is the V character mold with which a semi-conductor optical amplifier and 1i give the body of amplifier from the outside to the input light IN, and 2 gives gain, and spreads along the travelling direction of light, a coating layer with the reflection factor near [3L] 0% which makes light penetrate about 100%, and 6 are mirrors with a high reflection factor.

[0054] The semi-conductor optical amplifier 111 of the gestalt of this operation is what used the mirror 6 instead of coating layer 3H with the high reflection factor of the amplifier of the gestalt 10 of operation, and the actuation of it etc. is the same as that of the gestalt 10 of operation. Thereby, it becomes unnecessary to prepare two or more sorts of coating layers, and the location of a part with a high reflection factor can be moved easily.

[0055] The sectional view and drawing 13 which show roughly the configuration of the semi-conductor optical amplifier according [gestalt 12. drawing 12 of operation] to the gestalt 12 of implementation of this invention are that side-face sectional view. In both drawings 112 the body of amplifier, and 2 for a semi-conductor optical amplifier and 1j The gain field of a winding path mold, A coating layer with the reflection factor near [3L] 0% which makes light penetrate about 100%, A coating layer with the reflection factor by which 3M were optimized from the amplification factor, the coating layer whose reflection factor of 3H is 100%, the semiconductor laser component from which 7 becomes the generation source of the light by which incidence is carried out to body of amplifier 1j, and 8 are the bases which carried body of amplifier 1j, and the semiconductor laser component 7.

[0056] In the semi-conductor optical amplifier 112 of the gestalt of this operation, since the semiconductor laser component 7 and body of amplifier 1j have been arranged on the single base 8, optical-axis adjustment can be performed easily.

[0057] Gestalt 13. drawing 14 of operation is the sectional view showing roughly the configuration of the semi-conductor optical amplifier by the gestalt 13 of implementation of this invention. It consists of two or more gain field 2bs prolonged in gain field 2a to which 113 is prolonged in a gain field in a semi-conductor optical amplifier, and 2 prolongs in a drawing lengthwise direction, and a longitudinal direction in drawing. 9 is the grating prepared in the location where gain field 2a and 2b cross, and this is made into a desirable configuration according to the reflection factor of a request of the slot of fixed spacing of a diffraction grating. 3L and 3H are a coating layer with the reflection factor respectively near 0%, and a coating layer whose reflection factor is 100%. In addition, the oscillation section 10 which gain field 2a which formed the grating 9 equipped with partial side luminescence laser structure is constituted, and two or more gain field 2bs prolonged in a drawing longitudinal direction constitute an amplifier 11.

[0058] In the semi-conductor optical amplifier 113 of the gestalt of this operation, the gain field 2 of one semiconductor laser component crosses, laser resonance takes place in the part to which the

grating 9 of gain field 2a was attached, it is reflected in lateral gain field 2b, respectively, and outgoing radiation of the laser beam is carried out in response to magnification. The semi-conductor optical amplifier which constituted by this the oscillation section which generates light, and the amplifier which amplifies this in the single component is obtained.

[0059] Gestalt 14. drawing 15 of operation is the sectional view showing roughly the configuration of the semi-conductor optical amplifier by the gestalt 14 of implementation of this invention. The oscillation component in which gain field 2a in which 114 contains a semi-conductor optical amplifier in, and 12 contains a grating 9 was prepared in drawing and which consists of a partial side luminescence laser component, for example, The amplifier which prepared two or more gain field 2bs which amplify the light from which 13 was generated with the oscillation component 12, The base which carried the oscillation component 12 and the amplifier 13 like drawing 12 and drawing 13 as for 8, and 3L and 3H are a coating layer with the reflection factor respectively near 0%, and a coating layer whose reflection factor is 100%. In addition, the oscillation component 12 constitutes the oscillation section and an amplifier 13 constitutes an amplifier.

[0060] In the semi-conductor optical amplifier 114 of the gestalt of this operation, since it has the oscillation component 12 which attached the grating 9 to gain field 2a partially, and specified the direction of outgoing radiation, and the amplifier 13 by which the light from this oscillation component 12 prepared gain field 2b in the location by which incidence is carried out on the single base 8, optical-axis adjustment becomes easy.

[0061] Gestalt 15. drawing 16 of operation is the sectional view showing roughly the configuration of the semi-conductor optical amplifier by the gestalt 15 of implementation of this invention. Between the oscillation components 12 and amplifiers 13 of the amplifier of the gestalt 14 of operation of drawing 15 , the semi-conductor optical amplifier 115 of the gestalt of this operation is optical transparence, and it forms the insulator 14 with a high refractive index so that the diffraction of light may become small. Since the oscillation component 12 and an amplifier 13 were insulated electrically, respectively, it does not interfere electrically mutually, and while it is still more nearly mutual, the diffraction of light becomes small, and it enabled it to generate light more efficiently by this. In addition, this insulator 14 consists of quartz glass, Xtal, or an acrylic board.

[0062] Gestalt 16. drawing 17 of operation is the sectional view showing roughly the configuration of the semi-conductor optical amplifier by the gestalt 16 of implementation of this invention. In drawing, the semi-conductor optical amplifier whose 116 is a field luminescence semiconductor laser component, the gain field in which, as for 2, the grating 9 was formed, and 3L and 3H are a coating layer with the reflection factor respectively near 0%, and a coating layer whose reflection factor is 100%.

[0063] A reflection factor sets to coating layer 3L near 0% the side by which incidence is carried out, and the input light IN enabled it to obtain high power light easily in the semi-conductor optical amplifier 116 of the gestalt of this operation, so that the incidence of the input light IN from the outside can be carried out to the gain field 2 of the semi-conductor optical amplifier 116 which is a field luminescence semiconductor laser component.

[0064] Gestalt 17. drawing 18 of operation is the sectional view showing roughly the configuration of the semi-conductor optical amplifier by the gestalt 17 of implementation of this invention. The semi-conductor optical amplifier 117 of the gestalt of this operation prepares grating 9a which adjusted the daily dose of a grating 9 of the amplifier of the gestalt 16 of operation of drawing 17 (die length), and adjusted the magnification luminous intensity which carries out outgoing radiation.

[0065] Gestalt 18. drawing 19 of operation is the sectional view showing roughly the configuration of the semi-conductor optical amplifier by the gestalt 18 of implementation of this invention. In the semi-conductor optical amplifier 118 of the gestalt of this operation, coating layer 3H in which the light which passes through the gain field 2 to the amplifier of the gestalten 16 and 17 of operation, and escapes from a component end face to it is reflected similarly to the direction of the outgoing radiation light deflected by the grating 9 are prepared, and it was made to carry out outgoing radiation of the light more efficiently. In addition, coating layer 3H constitute the reflective section.

[0066] As mentioned above, in the 1st thru/or invention of the 5th of this invention, since a single semi-conductor optical amplifier can perform branching and magnification of light, the miniaturization of equipment can be realized and effectiveness, like high power-ization can be

performed with a single semi-conductor optical amplifier again is acquired. Especially, by the 3rd invention, since the gain field was used as the winding path mold, more output light can be obtained. Moreover, by invention of the 4th and 5, the direction of outgoing radiation of output light can be limited by the thing of a coating layer for which class selection is made.

[0067] Moreover, in the 6th of this invention thru/or invention of 8, since it was made the shape of a rectangle so that a gain field might be reflected in order in the side where the body of amplifier adjoins, effectiveness, like outgoing radiation of the light amplified from three or four fields of amplifier can be carried out is acquired.

[0068] Moreover, in invention of the 9th of this invention, the configuration of being able to double the phase of the output light which carries out outgoing radiation is obtained from each part by forming a thermoregulator and adjusting the temperature of the body of amplifier.

[0069] Moreover, in the 10th of this invention thru/or invention of 12, since the convex type tee or the concave tee was prepared in the end face of the body of amplifier, light can be branched to a 2-way at once.

[0070] Moreover, since the field where reflection factors differ was prepared, and a part of amplified light is reflected and it was made to penetrate a part in the part which the light amplified in the amplifier which has a taper-like gain field in the 13th of this invention thru/or especially invention of 15 reflects, effectiveness -- waveguide cannot become [magnitude of outgoing radiation opening] large too much -- is acquired.

[0071] Moreover, in invention of the 16th of this invention, since the gain field was made into the shape of a taper which spreads along the travelling direction of light and gain always becomes fixed, effectiveness -- a larger amplification factor is obtained -- is acquired.

[0072] Moreover, in invention of the 17th of this invention, since the semiconductor laser component and the body of amplifier have been arranged on the same base, effectiveness, like optical-axis adjustment can be performed easily is acquired.

[0073] Moreover, since the oscillation section which generates light, and the amplifier which amplifies this were made into 1 set and constituted from the 18th of this invention thru/or invention of 21, effectiveness, like optical-axis adjustment can be performed easily is acquired. Moreover, since it constituted from the 19th invention as a single component especially, effectiveness, like the miniaturization of equipment is attained further is acquired. Moreover, especially, by the 21st invention, since the oscillation component and the amplifier were carried on the same base, the insulator with a high refractive index was further formed by optical transparence among these components and between components is insulated electrically, it does not interfere electrically mutually, and while it is still more nearly mutual, the diffraction of light becomes small, and effectiveness, like light can be generated more efficiently is acquired.

[0074] Moreover, in the 22nd of this invention thru/or invention of 24, since input light used as the coating layer with the reflection factor near 0% the side by which incidence is carried out so that the incidence of the input light from the outside could be carried out to the gain field of the semi-conductor optical amplifier which is a field luminescence semiconductor laser component, effectiveness -- high power light is obtained easily -- is acquired. Moreover, especially, by the 23rd invention, since the die length of the grating formed in a gain field was adjusted, the effectiveness of being able to adjust the luminous intensity by which outgoing radiation is carried out is acquired. Moreover, especially, by the 24th invention, since the reflective section which reflects the light which passed gain gain in the same direction as the light deflected by the grating was prepared, effectiveness [be / no futility], like the outgoing radiation of the light can be carried out more efficiently is acquired.

[Translation done.]

* NOTICES *

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2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the sectional view showing roughly the configuration of the semi-conductor optical amplifier by the gestalt 1 of implementation of this invention.
[Drawing 2] It is the sectional view showing roughly the configuration of the semi-conductor optical amplifier by the gestalt 2 of implementation of this invention.
[Drawing 3] It is the sectional view showing roughly the configuration of the semi-conductor optical amplifier by the gestalt 3 of implementation of this invention.
[Drawing 4] It is the sectional view showing roughly the configuration of the semi-conductor optical amplifier by the gestalt 4 of implementation of this invention.
[Drawing 5] It is the sectional view showing roughly the configuration of the semi-conductor optical amplifier by the gestalt 5 of implementation of this invention.
[Drawing 6] It is the sectional view showing roughly the configuration of the semi-conductor optical amplifier by the gestalt 6 of implementation of this invention.
[Drawing 7] It is the sectional view showing roughly the configuration of the semi-conductor optical amplifier by the gestalt 7 of implementation of this invention.
[Drawing 8] It is the sectional view showing roughly the configuration of the semi-conductor optical amplifier by the gestalt 8 of implementation of this invention.
[Drawing 9] It is the sectional view showing roughly the configuration of the semi-conductor optical amplifier by the gestalt 9 of implementation of this invention.
[Drawing 10] It is the sectional view showing roughly the configuration of the semi-conductor optical amplifier by the gestalt 10 of implementation of this invention.
[Drawing 11] It is the sectional view showing roughly the configuration of the semi-conductor optical amplifier by the gestalt 11 of implementation of this invention.
[Drawing 12] It is the sectional view showing roughly the configuration of the semi-conductor optical amplifier by the gestalt 12 of implementation of this invention.
[Drawing 13] It is the side-face sectional view showing roughly the configuration of the semi-conductor optical amplifier by the gestalt 12 of implementation of this invention.
[Drawing 14] It is the sectional view showing roughly the configuration of the semi-conductor optical amplifier by the gestalt 13 of implementation of this invention.
[Drawing 15] It is the sectional view showing roughly the configuration of the semi-conductor optical amplifier by the gestalt 14 of implementation of this invention.
[Drawing 16] It is the sectional view showing roughly the configuration of the semi-conductor optical amplifier by the gestalt 15 of implementation of this invention.
[Drawing 17] It is the sectional view showing roughly the configuration of the semi-conductor optical amplifier by the gestalt 16 of implementation of this invention.
[Drawing 18] It is the sectional view showing roughly the configuration of the semi-conductor optical amplifier by the gestalt 17 of implementation of this invention.
[Drawing 19] It is the side-face sectional view showing roughly the configuration of the semi-conductor optical amplifier by the gestalt 18 of implementation of this invention.
[Drawing 20] It is the sectional view showing the configuration of the semi-conductor optical amplifier which has the general conventional semiconductor laser structure.
[Description of Notations]

A 1a - 1k concave tee, 6 mirror, 7 semiconductor laser component, 8 base, 9, and 9a grating, 10 oscillation section, 11 amplifier, 12 oscillation component, 13 amplifier, 14 insulators, 101 - 118 semi-conductor optical amplifier. The body of a semi-conductor optical amplifier, 2 and 2a, 2b A gain field, 3L, 3M, 3H A coating layer, 4 A heat regulator, 5a A convex type tee, 5b

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[Translation done.]

* NOTICES *

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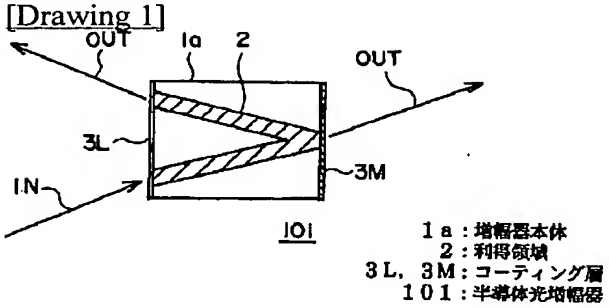
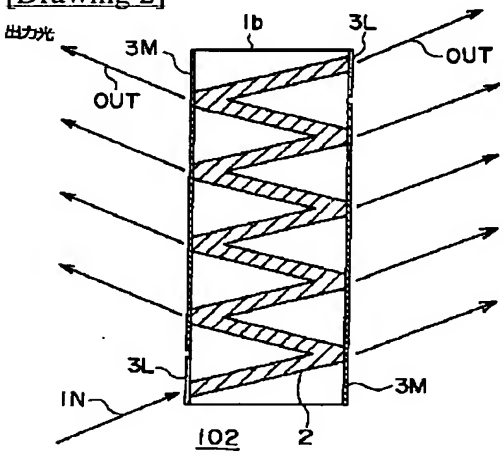
DRAWINGS

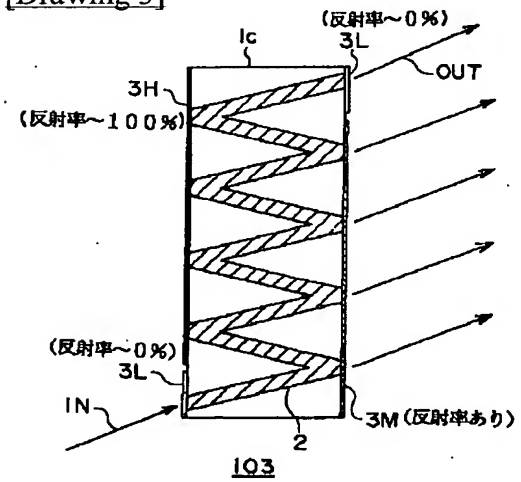
[Drawing 1]



[Drawing 2]



[Drawing 3]



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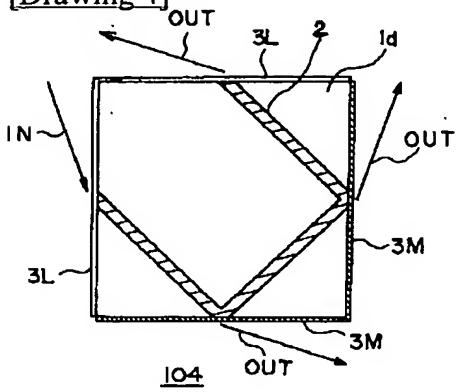
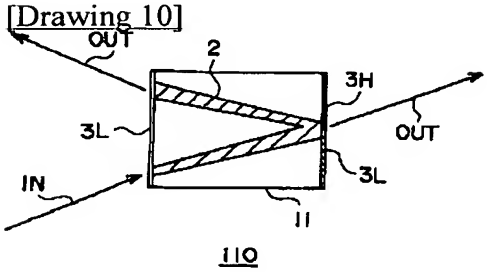
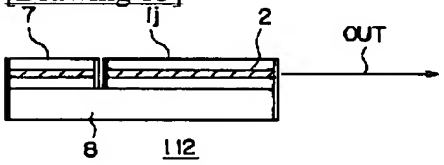


[Drawing 10]



[Drawing 13]



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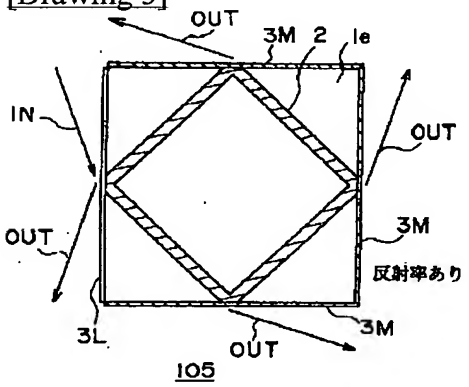

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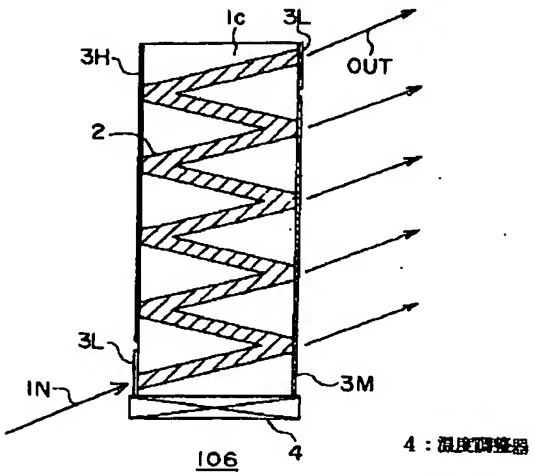

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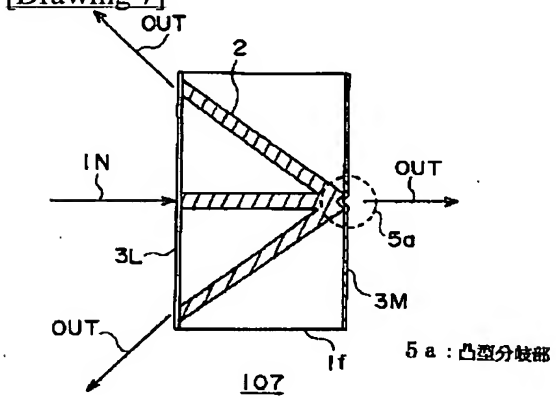

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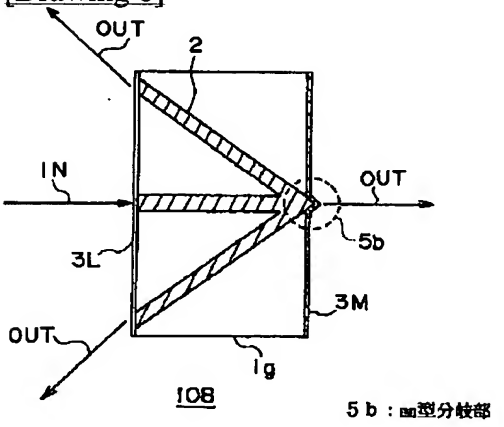

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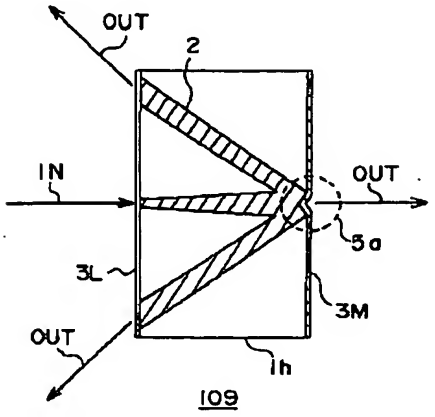

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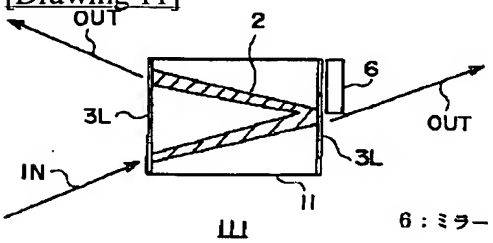
[Drawing 11]



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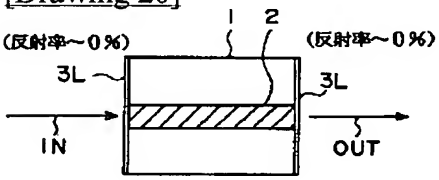
6：ミラー

[Drawing 20]



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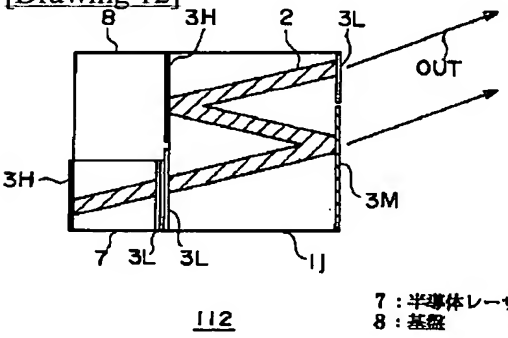
[Drawing 12]



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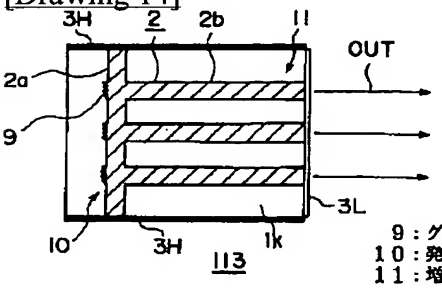
7：半導体レーザ素子
8：基盤

[Drawing 14]



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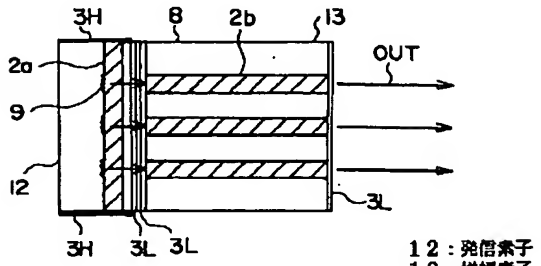
9：グレーディング
10：発振部
11：増幅部

[Drawing 15]



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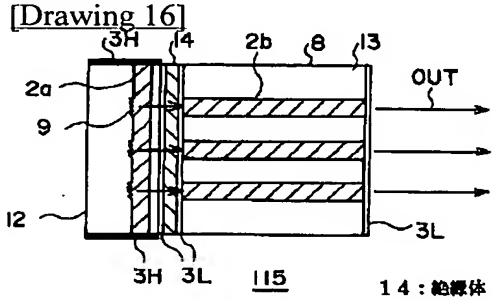
[Drawing 16]



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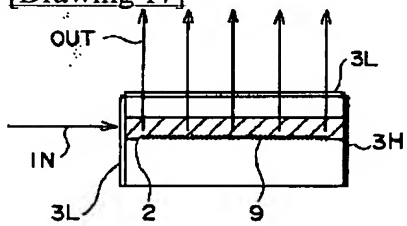
[Drawing 17]



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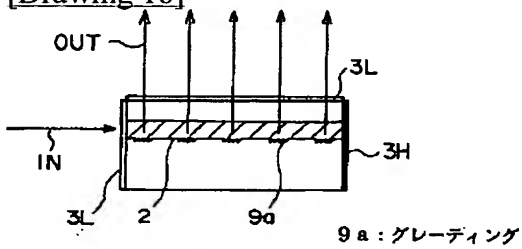
[Drawing 18]



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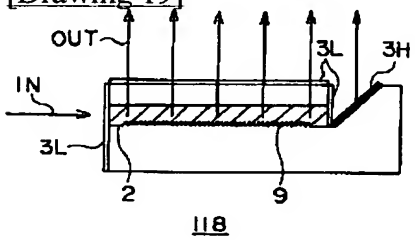
[Drawing 19]



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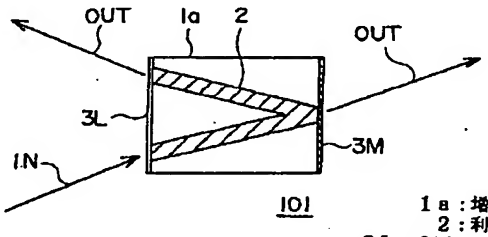
(54)【発明の名称】　半導体光増幅器

(57)【要約】

【課題】　光の分岐と増幅を単一の半導体光増幅器で行い、装置の小型化を図ると共に単一の半導体光増幅器当たりの利得領域を大きくして大出力化を実現する。

【解決手段】　半導体光増幅器１０１に入射された外部からの入力光ＩＮは、利得領域２で増幅されて増幅器本体１ａの右端に達する。光の一部はコーティング層３Ｍを透過して半導体光増幅器１０１の外部へと出射する出力光ＯＵＴとなるが、一部は反射されて増幅器本体１ａの左端へと増幅を受けたのとは別経路の利得領域２を通過して増幅される。



1a：増幅器本体
2：利得領域
3L，3M：コーティング層
101：半導体光増幅器

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【特許請求の範囲】

【請求項１】　外部からの光に利得を与える利得領域を有する半導体レーザ構造を設けた半導体光増幅器であって、半導体光増幅器本体の外面に所望の反射率を有するコーティング層が設けられ、外部から入力されて増幅された光を上記半導体光増幅器本体の内部端面の上記コーティング層にて内側に反射するとともに、一部を透過させて外部に出射させることを特徴とする半導体光増幅器。

【請求項２】　上記利得領域が、上記半導体光増幅器本体の両端面の間を往復するＶ字型のものからなることを特徴とする請求項１に記載の半導体光増幅器。

【請求項３】　上記利得領域が、上記半導体光増幅器本体の両端面の間を複数回往復するつづら折り型のものからなることを特徴とする請求項１に記載の半導体光増幅器。

【請求項４】　上記半導体光増幅器本体の両端面の両面側から光が出射されることを特徴とする請求項３に記載の半導体光増幅器。

【請求項５】　上記半導体光増幅器本体の両端面の片面側から光が出射されることを特徴とする請求項３に記載の半導体光増幅器。

【請求項６】　上記半導体光増幅器本体が矩形状のものからなり、上記利得領域が上記半導体光増幅器本体の隣接する辺で順に反射する矩形状のものからなることを特徴とする請求項１に記載の半導体光増幅器。

【請求項７】　上記半導体光増幅器本体の３つの面側から光を出射させることを特徴とする請求項６に記載の半導体光増幅器。

【請求項８】　上記半導体光増幅器本体の４つの面側から光を出射させることを特徴とする請求項６に記載の半導体光増幅器。

【請求項９】　上記半導体光増幅器の複数の箇所で上記反射および出謝がそれぞれ行われ、上記半導体光増幅器外部に出射された光の位相を揃えるために上記半導体光増幅器の温度調整を行う温度調整手段をさらに備えたことを特徴とする請求項１に記載の半導体光増幅器。

【請求項１０】　上記半導体光増幅器本体およびその外面のコーティング層が、光を内側の２方向に反射する分岐部を有し、上記利得領域がこれに従って分岐するように形成されていることを特徴とする請求項１に記載の半導体光増幅器。

【請求項１１】　上記分岐部が、内側にＶ字型に突出した凸型分岐部からなることを特徴とする請求項１０に記載の半導体光増幅器。

【請求項１２】　上記分岐部が、外側にＶ字型に突出した凹型分岐部からなることを特徴とする請求項１０に記載の半導体光増幅器。

【請求項１３】　上記半導体光増幅器の端面が、反射率がそれぞれ異なる領域を有し、増幅された光の一部を反

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射し一部を透過することを特徴とする請求項１に記載の半導体光増幅器。

【請求項１４】　上記半導体光増幅器本体の外面に異なる反射率を有する複数のコーティング層を設けてなることを特徴とする請求項１３に記載の半導体光増幅器。

【請求項１５】　上記半導体光増幅器本体の外面に設けられたコーティング層と、その外側に部分的に設けられたミラーでなることを特徴とする請求項１３に記載の半導体光増幅器。

【請求項１６】　上記利得領域を光の進行方向に沿って拡がるテーパ状にし、上記利得領域に沿って利得を一定にしたことを特徴とする請求項１ないし１５のいずれかに記載の半導体光増幅器。

【請求項１７】　上記半導体光増幅器に入射させる光の発生源としての半導体レーザ素子を単一の素子上で組み合わせて設けたことを特徴とする請求項１に記載の半導体光増幅器。

【請求項１８】　光を発生する発振部と、これにより発生された光に利得を与えて増幅する増幅部と、からなることを特徴とする半導体光増幅器。

【請求項１９】　利得領域の一部にグレーティングを設け所望の位置に光を送る上記発振部と、送られてきた光の進行方向に利得領域を設けた上記増幅部とが、単一素子として形成されたことを特徴とする請求項１８に記載の半導体光増幅器。

【請求項２０】　上記発振部が所要の位置に光を出射するようにグレーティングを設けた発振素子からなり、上記増幅部がその出射された光の位置に一致した利得領域を持つ増幅素子からなる、これらが１つの基盤上に搭載されたことを特徴とする請求項１８に記載の半導体光増幅器。

【請求項２１】　上記発振素子と増幅素子の間に光学的に透明な絶縁体を挟み、双方の間の電気区分を付けたことを特徴とする請求項２０に記載の半導体光増幅器。

【請求項２２】　面発光半導体レーザ素子のグレーティングが形成された利得領域に外部から光を入射できるように、光を入射する側に反射率が０％に近いコーティング層を設けたことを特徴とする半導体光増幅器。

【請求項２３】　上記面発光半導体レーザ素子の利得領域のグレーティングを付ける領域の長さを調整し、出力される光の強度を調整するようにしたことを特徴とする請求項２２に記載の半導体光増幅器。

【請求項２４】　上記利得領域を通過した光を上記グレーティングで偏向された出射光と同じ方向に反射させる反射部をさらに設けたことを特徴とする請求項２２または２３に記載の半導体光増幅器。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】この発明は、主として光通信、光応用計測、光情報処理用光源、固体レーザ励起用

光源として用いられる進行波型の半導体光増幅器に関する。

【０００２】

【従来の技術】図２０は一般的な従来の半導体レーザ構造を有する半導体光増幅器の構成を示す断面図であり、図において、１００は半導体光増幅器、１は半導体光増幅器本体(以下増幅器本体とする)、２は外部からの入力光ＩＮに利得を与える利得領域、３Ｌは増幅器本体１の外面にコーティングされている反射率を極力小さくするコーティング層、ＯＵＴは半導体光増幅器１００の外部に出射される出力光である。

【０００３】次に動作について説明する。外部からの入力光ＩＮが増幅器本体１内の利得領域２を通過すると、外部からの光は利得を得て増幅される。

【０００４】

【発明が解決しようとする課題】以上のように構成された従来の半導体光増幅器では、増幅だけを行っていたため、光を分岐させて複数の回線に同一の情報を伝搬する通信の場合等においては、光の増幅と分岐がそれぞれ別々の素子で行われているために、装置全体が大きくなってしまっていた。また、波長制御された光を半導体光増幅器を用いて大出力化する場合、単一の半導体光増幅器の一つの利得領域を大きくするのには限度があり、得られる出力に限界があった。

【０００５】この発明は上記のような課題を解消するためになされたもので、光の分岐と増幅の両方を行うことができ、また、単一の半導体光増幅器の全利得領域を広くすることで大出力を発生することのできる半導体光増幅器を得ることを目的とする。

【０００６】

【課題を解決するための手段】上記の目的に鑑み、この発明の第１の発明は、外部からの光に利得を与える利得領域を有する半導体レーザ構造を設けた半導体光増幅器であって、半導体光増幅器本体の外面に所望の反射率を有するコーティング層が設けられ、外部から入力されて増幅された光を上記半導体光増幅器本体の内部端面の上記コーティング層にて内側に反射するとともに、一部を透過させて外部に出射させることを特徴とする半導体光増幅器にある。

【０００７】この発明の第２の発明は、上記利得領域が、上記半導体光増幅器本体の両端面の間を往復するＶ字型のものからなることを特徴とする請求項１に記載の半導体光増幅器にある。

【０００８】この発明の第３の発明は、上記利得領域が、上記半導体光増幅器本体の両端面の間を複数回往復するつづら折り型のものからなることを特徴とする請求項１に記載の半導体光増幅器にある。

【０００９】この発明の第４の発明は、上記半導体光増幅器本体の両端面の両面側から光が出射されることを特徴とする請求項３に記載の半導体光増幅器にある。

【００１０】この発明の第５の発明は、上記半導体光増幅器本体の両端面の片面側から光が出射されることを特徴とする請求項３に記載の半導体光増幅器にある。

【００１１】この発明の第６の発明は、上記半導体光増幅器本体が矩形状のものからなり、上記利得領域が上記半導体光増幅器本体の隣接する辺で順に反射する矩形状のものからなることを特徴とする請求項１に記載の半導体光増幅器にある。

【００１２】この発明の第７の発明は、上記半導体光増幅器本体の３つの面側から光を出射させることを特徴とする請求項６に記載の半導体光増幅器にある。

【００１３】この発明の第８の発明は、上記半導体光増幅器本体の４つの面側から光を出射させることを特徴とする請求項６に記載の半導体光増幅器にある。

【００１４】この発明の第９の発明は、上記半導体光増幅器の複数の箇所で上記反射および出謝がそれぞれ行われ、上記半導体光増幅器外部に出射された光の位相を揃えるために上記半導体光増幅器の温度調整を行う温度調整手段をさらに備えたことを特徴とする請求項１に記載の半導体光増幅器にある。

【００１５】この発明の第１０の発明は、上記半導体光増幅器本体およびその外面のコーティング層が、光を内側の２方向に反射する分岐部を有し、上記利得領域がこれに従って分岐するように形成されていることを特徴とする請求項１に記載の半導体光増幅器にある。

【００１６】この発明の第１１の発明は、上記分岐部が、内側にＶ字型に突出した凸型分岐部からなることを特徴とする請求項１０に記載の半導体光増幅器にある。

【００１７】この発明の第１２の発明は、上記分岐部が、外側にＶ字型に突出した凹型分岐部からなることを特徴とする請求項１０に記載の半導体光増幅器にある。

【００１８】この発明の第１３の発明は、上記半導体光増幅器の端面が、反射率がそれぞれ異なる領域を有し、増幅された光の一部を反射し一部を透過することを特徴とする請求項１に記載の半導体光増幅器にある。

【００１９】この発明の第１４の発明は、上記半導体光増幅器本体の外面に異なる反射率を有する複数のコーティング層を設けてなることを特徴とする請求項１３に記載の半導体光増幅器にある。

【００２０】この発明の第１５の発明は、上記半導体光増幅器本体の外面に設けられたコーティング層と、その外側に部分的に設けられたミラーでなることを特徴とする請求項１３に記載の半導体光増幅器にある。

【００２１】この発明の第１６の発明は、上記利得領域を光の進行方向に沿って拡がるテーパ状にし、上記利得領域に沿って利得を一定にしたことを特徴とする請求項１ないし１５のいずれかに記載の半導体光増幅器にある。

【００２２】この発明のだ１７の発明は、上記半導体光増幅器に入射させる光の発生源としての半導体レーザ素

子を単一の素子上で組み合わせて設けたことを特徴とする請求項１に記載の半導体光増幅器にある。

【００２３】この発明の第１８の発明は、光を発生する発振部と、これにより発生された光に利得を与えて増幅する増幅部と、からなることを特徴とする半導体光増幅器にある。

【００２４】この発明の第１９の発明は、利得領域の一部にグレーティングを設け所望の位置に光を送る上記発振部と、送られてきた光の進行方向に利得領域を設けた上記増幅部とが、単一素子として形成されたことを特徴とする請求項１８に記載の半導体光増幅器にある。

【００２５】この発明の第２０の発明は、上記発振部が所要の位置に光を出射するようにグレーティングを設けた発振素子からなり、上記増幅部がその出射された光の位置に一致した利得領域を持つ増幅素子からなる、これらが１つの基盤上に搭載されたことを特徴とする請求項１８に記載の半導体光増幅器にある。

【００２６】この発明の第２１の発明は、上記発振素子と増幅素子の間に光学的に透明な絶縁体を挟み、双方の間の電気区分を付けたことを特徴とする請求項２０に記載の半導体光増幅器にある。

【００２７】この発明の第２２の発明は、面発光半導体レーザ素子のグレーティングが形成された利得領域に外部から光を入射できるように、光を入射する側に反射率が０％に近いコーティング層を設けたことを特徴とする半導体光増幅器にある。

【００２８】この発明の第２３の発明は、上記面発光半導体レーザ素子の利得領域のグレーティングを付ける領域の長さを調整し、出力される光の強度を調整するようにしたことを特徴とする請求項２２に記載の半導体光増幅器にある。

【００２９】この発明の第２４の発明は、上記利得領域を通過した光を上記グレーティングで偏向された出射光と同じ方向に反射させる反射部をさらに設けたことを特徴とする請求項２２および２３のいずれかに記載の半導体光増幅器にある。

【００３０】

【発明の実施の形態】以下、この発明の実施の形態について説明する。

実施の形態１．図１はこの発明の実施の形態１による半導体光増幅器の構成を概略的に示す断面図である。図において、１０１は半導体光増幅器、１ａは半導体光増幅器本体（以下増幅器本体とする）、２は外部からの入力光ＩＮに利得を与えるＶ字型の利得領域、３Ｌは増幅器本体１ａの端面に設けられた光を１００％近く透過させる反射率が０％に近いコーティング層、３Ｍは増幅率から最適化された反射率を持つコーティング層である。

【００３１】次に動作につてい説明すると、図１の左側から半導体光増幅器１０１に入射された外部からの入力光ＩＮは、利得領域２で増幅されて増幅器本体１ａの右端に達する。光の一部はコーティング層３Ｍを透過して半導体光増幅器１０１の外部へと出射する出力光ＯＵＴとなるが、一部は反射されて増幅器本体１ａの左端へと増幅を受けたのとは別経路の利得領域２を通過して増幅される。

【００３２】そして増幅器本体１ａの左端に達した増幅光はコーティング層３Ｌを透過して半導体光増幅器１０１の外部へと出射される。この結果、増幅光は半導体光増幅器１０１の左右端から出射されるので、外部からの入力光ＩＮの増幅と分岐を同時に行ったことになる。なお、利得領域２での増幅率とコーティング層での反射率を適当に選択すれば、半導体光増幅器１０１の左右端で同じ大きさの出力光ＯＵＴを得ることもできる。

【００３３】実施の形態２．図２はこの発明の実施の形態２による半導体光増幅器の構成を概略的に示す断面図である。図において、１０２は半導体光増幅器、１ｂは増幅器本体、２は外部からの入力光ＩＮに利得を与えるつづら折り型の利得領域、３Ｌは光を１００％近く透過させる反射率が０％に近いコーティング層、３Ｍは増幅率から最適化された反射率を持つコーティング層である。

【００３４】動作原理は上記実施の形態１と同じであるが、実施の形態２では利得領域２が増幅器本体１ｂの両端面の間を複数回往復するつづら折り型のものになっており、光の分岐が複数回行われる。また、出力光ＯＵＴは半導体光増幅器１０２の左右端側から出射される。これにより、より多くの出力光ＯＵＴを得ることができる。

【００３５】実施の形態３．図３はこの発明の実施の形態３による半導体光増幅器の構成を概略的に示す断面図である。図において、１０３は半導体光増幅器、１ｃは増幅器本体、２は外部からの入力光ＩＮに利得を与えるつづら折り型の利得領域、３Ｌは光を１００％近く透過させる反射率が０％に近いコーティング層、３Ｍは増幅率から最適化された反射率を持つコーティング層、３Ｈは反射率が１００％のコーティング層である。

【００３６】この実施の形態では、増幅器本体１ｃの片側の端面に反射率が１００％のコーティング層３Ｈを設けることにより、出力光ＯＵＴを半導体光増幅器１０３の片側から出射させるようにし、出力光ＯＵＴの出射方向を制限している。

【００３７】実施の形態４．図４はこの発明の実施の形態４による半導体光増幅器の構成を概略的に示す断面図である。図において、１０４は半導体光増幅器、１ｄは矩形状の増幅器本体、２は外部からの入力光ＩＮに利得を与える矩形状の利得領域、３Ｌは光を１００％近く透過させる反射率が０％に近いコーティング層、３Ｍは増幅率から最適化された反射率を持つコーティング層である。

【００３８】この実施の形態の半導体光増幅器１０４で

は、外部からの光に利得を与える利得領域2が、増幅器本体1dの隣接する辺で順に反射するようにコの字型にされており、半導体光増幅器104の両側端面だけでなく、これらと直交する方向に延びる側面の一方でも反射と出射が行われ、増幅された出力光OUTを3方向に出射させることができる。

【0039】実施の形態5．図5はこの発明の実施の形態5による半導体光増幅器の構成を概略的に示す断面図である。図において、105は半導体光増幅器、1eは矩形状の増幅器本体、2は外部からの入力光INに利得を与える矩形状の利得領域、3Lは光を100%近く透過させる反射率が0%に近いコーティング層、3Mは増幅率から最適化された反射率を持つコーティング層である。

【0040】この実施の形態の半導体光増幅器105では、外部からの光に利得を与える利得領域2が、増幅器本体1eの隣接する辺で順に反射するようにロの字型にされており、半導体光増幅器105の両側端面だけでなく、これの両側の側面でもそれぞれ反射と出射が行われ、増幅された出力光OUTを4方向に出射させることができる。

【0041】実施の形態6．図6はこの発明の実施の形態6による半導体光増幅器の構成を概略的に示す断面図である。図において、半導体光増幅器106は図3の増幅器に温度調整手段を構成する温度調整器4を備えたものである。この実施の形態では、温度調整器4を付加して増幅器本体1cの温度を調整するたことにより、各部分から出射する出力光OUTの位相を合わせることができる。

【0042】なお、温度調整器4はヒータで構成すればよいが、好ましくは温度精度の高い例えばペルチェクーラと呼ばれる半導体素子で構成するとよい。また、この実施の形態は図3の増幅器に限らず、複数の出力光を出射する増幅器全てに適用でき、同様な効果が得られる。

【0043】実施の形態7．図7はこの発明の実施の形態7による半導体光増幅器の構成を概略的に示す断面図である。図において、107は半導体光増幅器、1fは増幅器本体、2は外部からの入力光INに利得を与える矢印型の利得領域、3Lは光を100%近く透過させる反射率が0%に近いコーティング層、3Mは増幅率から最適化された反射率を持つコーティング層、そして5aは増幅された光を両側2方向に分岐させる凸型分岐部である。この凸型分岐部5aは、増幅器本体1fの端面とコーティング層3Mがそれぞれ半導体光増幅器107の内側にV字型に突出して形成されている。

【0044】動作の原理は上述の各実施の形態と同じであるが、特に増幅器本体1fの端面の凸型分岐部5aにおける反射で、一度に2方向に光を分岐させることができる。

【0045】実施の形態8．図8はこの発明の実施の形態8による半導体光増幅器の構成を概略的に示す断面図である。図において、108は半導体光増幅器、1gは増幅器本体、2は外部からの入力光INに利得を与える矢印型の利得領域、3Lは光を100%近く透過させる反射率が0%に近いコーティング層、3Mは増幅率から最適化された反射率を持つコーティング層、そして5bは増幅された光を両側2方向に分岐させる凹型分岐部である。この凹型分岐部5bは、増幅器本体1gの端面とコーティング層3Mがそれぞれ半導体光増幅器108の外側にV字型に突出して形成されている。

【0046】実施の形態7と異なるとこは、分岐部が半導体光増幅器108の外側にV字型に突出した凹型分岐部5bで構成されている点で、他の動作および効果については実施の形態7と同じである。

【0047】実施の形態9．図9はこの発明の実施の形態9による半導体光増幅器の構成を概略的に示す断面図である。図において、109は半導体光増幅器、1hは増幅器本体、2は外部からの入力光INに利得を与える矢印型でかつ光の進行方向に沿って拡がるテーパ状の利得領域、3Lは光を100%近く透過させる反射率が0%に近いコーティング層、3Mは増幅率から最適化された反射率を持つコーティング層、そして5aは増幅された光を両側2方向に分岐させる凸型分岐部である。

【0048】この実施の形態の半導体光増幅器109は基本的には実施の形態7のものと同じであるが、利得領域2がテーパ状にされていることにより、利得が常に一定になるようにされており、これにより、より大きい増幅率が得られる。

【0049】伝搬ビームすなわち光は進行と共に拡がる。利得は光の強度によって変化するので、一定の利得を得るためには利得領域のサイズと光のサイズを一致させる必要がある。光の強度が強くなると、飽和現象により利得が低下する。従って増幅率を大きくするには、利得領域と光の形態を一致させるのがよい方法となる。そこでこの実施の形態では、利得領域2をテーパー状にした。

【0050】なお、利得領域2を光の進行方向に沿って拡がるテーパ状にすることは、この実施の形態に限定されることなく、他の実施の形態においても適用可能であり、同様な効果が得られる。

【0051】実施の形態10．図10はこの発明の実施の形態10による半導体光増幅器の構成を概略的に示す断面図である。図において、110は半導体光増幅器、1iは増幅器本体、2は外部からの入力光INに利得を与えるV字型でかつ光の進行方向に沿って拡がるテーパ状の利得領域、3Lは光を100%近く透過させる反射率が0%に近いコーティング層、3Hは反射率が100%のコーティング層である。

【0052】この実施の形態の半導体光増幅器110では、入射した外部からの入力光OUTは、利得領域2で

増幅されて増幅器本体１ｉの右端に達する。光の一部は反射率が０％に近いコーティング層３Ｌを透過して半導体光増幅器１１０の外部へと出射するが、一部は反射率が１００％のコーティング層３Ｈで反射されて増幅器本体１ｉの左端へと前述と別の経路の利得領域２を通過して増幅される。テーパ状の導波路すなわち利得領域２を用いて増幅を行う場合に、導波路が長くなる程、出射口の大きさが大きくなるが、この発明のように光の一部を切り出せば、導波路が長くなっても出射口の大きさが大きくなり過ぎることが無い。

【００５３】実施の形態１１．図１１はこの発明の実施の形態１１による半導体光増幅器の構成を概略的に示す断面図である。図において、１１１は半導体光増幅器、１ｉは増幅器本体、２は外部からの入力光ＩＮに利得を与えるＶ字型でかつ光の進行方向に沿って拡がるテーパ状の利得領域、３Ｌは光を１００％近く透過させる反射率が０％に近いコーティング層、６は反射率の高いミラーである。

【００５４】この実施の形態の半導体光増幅器１１１は、実施の形態１０の増幅器の反射率の高いコーティング層３Ｈの代わりミラー６を使用したもので、動作等は実施の形態１０と同じである。これにより、複数種のコーティング層を設ける必要がなくなり、また反射率の高い部分の位置を容易に移動できる。

【００５５】実施の形態１２．図１２はこの発明の実施の形態１２による半導体光増幅器の構成を概略的に示す断面図、図１３はその側面断面図である。両図において、１１２は半導体光増幅器、１ｊは増幅器本体、２はつづら折り型の利得領域、３Ｌは光を１００％近く透過させる反射率が０％に近いコーティング層、３Ｍは増幅率から最適化された反射率を持つコーティング層、３Ｈは反射率が１００％のコーティング層、７は増幅器本体１ｊに入射される光の発生源となる半導体レーザ素子、８は増幅器本体１ｊと半導体レーザ素子７を搭載した基盤である。

【００５６】この実施の形態の半導体光増幅器１１２では、単一の基盤８上に半導体レーザ素子７と増幅器本体１ｊを配置したので、光軸調整が容易に行える。

【００５７】実施の形態１３．図１４はこの発明の実施の形態１３による半導体光増幅器の構成を概略的に示す断面図である。図において、１１３は半導体光増幅器、２は利得領域で図面縦方向に延びる利得領域２ａと横方向に延びる複数の利得領域２ｂからなる。９は利得領域２ａと２ｂが交差する位置に設けられたグレーティングで、これは回折格子の一定間隔の溝を所望の反射率に従って望ましい形状にしたものである。３Ｌおよび３Ｈはそれぞれ反射率が０％に近いコーティング層と反射率が１００％のコーティング層である。なお、グレーティング９を設けた利得領域２ａが部分面発光レーザ構造を備えた発振部１０を構成し、図面横方向に延びる複数の利得領域２ｂが増幅部１１を構成する。

【００５８】この実施の形態の半導体光増幅器１１３では、一つの半導体レーザ素子の利得領域２が交差しており、利得領域２ａのグレーティング９の付いた部分においてレーザ共振が起こり、レーザ光は横方向の利得領域２ｂにそれぞれ反射され、増幅を受けて出射する。これにより、光を発生する発振部とこれを増幅する増幅部を単一素子内に構成した半導体光増幅器が得られる。

【００５９】実施の形態１４．図１５はこの発明の実施の形態１４による半導体光増幅器の構成を概略的に示す断面図である。図において、１１４は半導体光増幅器、１２はグレーティング９を含む利得領域２ａが設けられた例えば部分面発光レーザ素子からなる発振素子、１３は発振素子１２で発生された光を増幅する複数の利得領域２ｂを設けた増幅素子、８は図１２および図１３と同様に発振素子１２と増幅素子１３を搭載した基盤、３Ｌおよび３Ｈはそれぞれ反射率が０％に近いコーティング層と反射率が１００％のコーティング層である。なお、発振素子１２が発振部を構成し、増幅素子１３が増幅部を構成する。

【００６０】この実施の形態の半導体光増幅器１１４では、利得領域２ａに部分的にグレーティング９を付けて出射方向を規定した発振素子１２と、この発振素子１２からの光が入射される位置に利得領域２ｂを設けた増幅素子１３が、単一の基盤８上に備えられているために、光軸調整が容易になる。

【００６１】実施の形態１５．図１６はこの発明の実施の形態１５による半導体光増幅器の構成を概略的に示す断面図である。この実施の形態の半導体光増幅器１１５は、図１５の実施の形態１４の増幅器の、発振素子１２と増幅素子１３の間に光学的透明で、光の回折が小さくなるように屈折率が高い絶縁体１４を設けたものである。これにより、発振素子１２と増幅素子１３とがそれぞれ電気的に絶縁されるために、互いに電気的に干渉することがなく、さらに互いの間の光の回折が小さくなり、より効率良く光の発生が行えるようにした。なお、この絶縁体１４は例えば石英ガラス、水晶あるいはアクリル板等からなる。

【００６２】実施の形態１６．図１７はこの発明の実施の形態１６による半導体光増幅器の構成を概略的に示す断面図である。図において、１１６は面発光半導体レーザ素子である半導体光増幅器、２はグレーティング９が設けられた利得領域、３Ｌおよび３Ｈはそれぞれ反射率が０％に近いコーティング層と反射率が１００％のコーティング層である。

【００６３】この実施の形態の半導体光増幅器１１６では、面発光半導体レーザ素子である半導体光増幅器１１６の利得領域２に外部からの入力光ＩＮが入射できるように、入力光ＩＮが入射される側を反射率が０％に近いコーティング層３Ｌとし、容易に大出力光を得られるよ

うにした。

【００６４】実施の形態１７．図１８はこの発明の実施の形態１７による半導体光増幅器の構成を概略的に示す断面図である。この実施の形態の半導体光増幅器１１７は、図１７の実施の形態１６の増幅器の、グレーティング９の分量(長さ)を調節したグレーティング９ａを設け、出射する増幅光の強度を調整するようにした。

【００６５】実施の形態１８．図１９はこの発明の実施の形態１８による半導体光増幅器の構成を概略的に示す断面図である。この実施の形態の半導体光増幅器１１８では、実施の形態１６および１７の増幅器に、利得領域２を通過して素子端面から抜ける光をグレーティング９で偏向された出射光の方向と同じに反射させるコーティング層３Ｈを設けて、より効率良く光を出射するようにした。なお、コーティング層３Ｈが反射部を構成する。

【００６６】以上のように、この発明の第１ないし第５の発明では、単一の半導体光増幅器によって光の分岐と増幅が行えるので、装置の小型化が実現できまた単一の半導体光増幅器で大出力化ができる等の効果が得られる。特に第３の発明では、利得領域をつづら折り型にしたのでより多くの出力光を得ることができる。また第４および５の発明では、コーティング層の種類選択することで、出力光の出射方向を限定することができる。

【００６７】また、この発明の第６ないし８の発明では、利得領域を増幅器本体の隣接する辺で順に反射するように矩形状にしたので、増幅器の３つあるいは４つの面から増幅した光を出射させることができる等の効果が得られる。

【００６８】また、この発明の第９の発明では、温度調節器を設けて増幅器本体の温度を調整することにより、各部分から出射する出力光の位相を合わせることができる等の構成が得られる。

【００６９】また、この発明の第１０ないし１２の発明では、凸型分岐部あるいは凹型分岐部を増幅器本体の端面に設けたので、一度に２方向に光を分岐させることができる。

【００７０】また、この発明の第１３ないし１５の発明では、特にテーパ状の利得領域を有する増幅器において、増幅された光が反射する部分で、反射率が異なる領域を設け、増幅された光の一部を反射し一部を透過するようにしたので、導波路が長くなっても出射口の大きさが大きくなり過ぎることが無い等の効果が得られる。

【００７１】また、この発明の第１６の発明では、利得領域を光の進行方向に沿って拡がるテーパ状にしたので、利得が常に一定になるので、より大きい増幅率が得られる等の効果が得られる。

【００７２】また、この発明の第１７の発明では、同一の基盤上に半導体レーザ素子と増幅器本体を配置したので、光軸調整が容易に行える等の効果が得られる。

【００７３】また、この発明の第１８ないし２１の発明では、光を発生する発振部とこれを増幅する増幅部を１組にして構成したので、光軸調整が容易に行える等の効果が得られる。また特に第１９の発明では単一素子として構成したので、さらに装置の小型化が可能になる等の効果が得られる。また特に第２１の発明では、発振素子と増幅素子を同一基盤上に搭載し、さらにこれらの素子の間に光学的透明で屈折率が高い絶縁体を設けたので、素子間が電気的に絶縁されるために、互いに電気的に干渉することがなく、さらに互いの間の光の回折が小さくなり、より効率良く光の発生が行える等の効果が得られる。

【００７４】また、この発明の第２２ないし２４の発明では、面発光半導体レーザ素子である半導体光増幅器の利得領域に外部からの入力光が入射できるように、入力光が入射される側を反射率が０％に近いコーティング層としたので、容易に大出力光が得られる等の効果が得られる。また特に第２３の発明では、利得領域に形成されるグレーティングの長さを調整するようにしたので、出射される光の強度を調整することができる等の効果が得られる。また特に第２４の発明では、利得利得を通過した光をグレーティングで偏向された光と同じ方向に反射する反射部を設けたので、無駄なくより効率良く光を出射できる等の効果が得られる。

【図面の簡単な説明】

【図１】　この発明の実施の形態１による半導体光増幅器の構成を概略的に示す断面図である。

【図２】　この発明の実施の形態２による半導体光増幅器の構成を概略的に示す断面図である。

【図３】　この発明の実施の形態３による半導体光増幅器の構成を概略的に示す断面図である。

【図４】　この発明の実施の形態４による半導体光増幅器の構成を概略的に示す断面図である。

【図５】　この発明の実施の形態５による半導体光増幅器の構成を概略的に示す断面図である。

【図６】　この発明の実施の形態６による半導体光増幅器の構成を概略的に示す断面図である。

【図７】　この発明の実施の形態７による半導体光増幅器の構成を概略的に示す断面図である。

【図８】　この発明の実施の形態８による半導体光増幅器の構成を概略的に示す断面図である。

【図９】　この発明の実施の形態９による半導体光増幅器の構成を概略的に示す断面図である。

【図１０】　この発明の実施の形態１０による半導体光増幅器の構成を概略的に示す断面図である。

【図１１】　この発明の実施の形態１１による半導体光増幅器の構成を概略的に示す断面図である。

【図１２】　この発明の実施の形態１２による半導体光増幅器の構成を概略的に示す断面図である。

【図１３】　この発明の実施の形態１２による半導体光増幅器の構成を概略的に示す側面断面図である。

【図14】　この発明の実施の形態13による半導体光増幅器の構成を概略的に示す断面図である。

【図15】　この発明の実施の形態14による半導体光増幅器の構成を概略的に示す断面図である。

【図16】　この発明の実施の形態15による半導体光増幅器の構成を概略的に示す断面図である。

【図17】　この発明の実施の形態16による半導体光増幅器の構成を概略的に示す断面図である。

【図18】　この発明の実施の形態17による半導体光増幅器の構成を概略的に示す断面図である。

【図19】　この発明の実施の形態18による半導体光

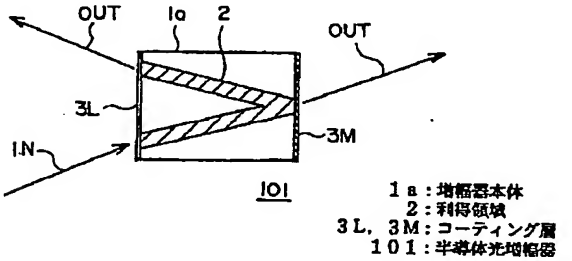
増幅器の構成を概略的に示す側面断面図である。

【図20】　一般的な従来の半導体レーザ構造を有する半導体光増幅器の構成を示す断面図である。

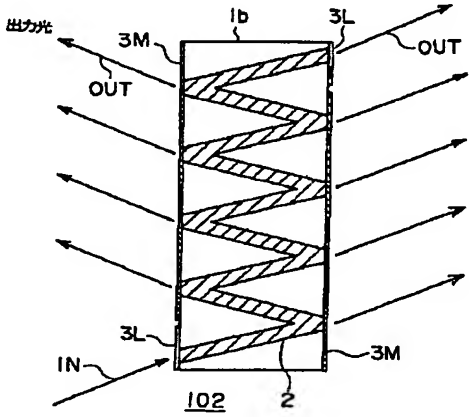
【符号の説明】

1a～1k　半導体光増幅器本体、2，2a，2b　利得領域、3L，3M，3H　コーティング層、4　温度調整器、5a　凸型分岐部、5b　凹型分岐部、6　ミラー、7　半導体レーザ素子、8　基盤、9，9a　グレーティング、10　発振部、11　増幅部、12　発振素子、13　増幅素子、14　絶縁体、101～118　半導体光増幅器。

【図1】



【図2】



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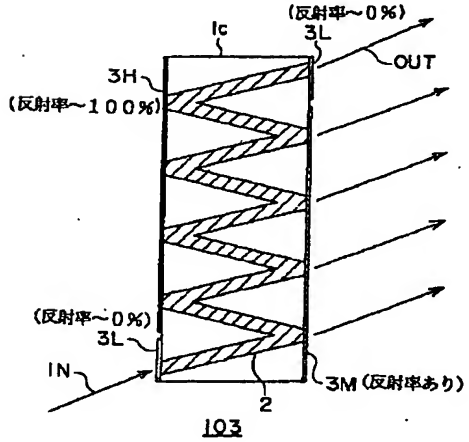

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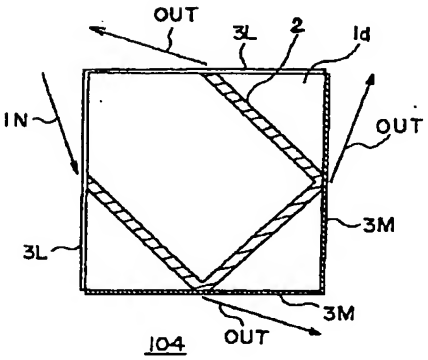

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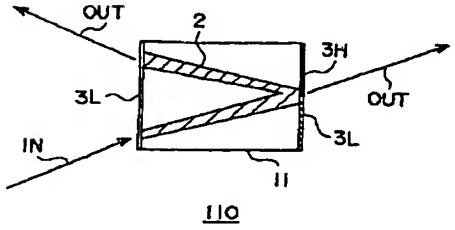
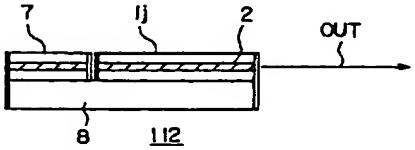


【図13】



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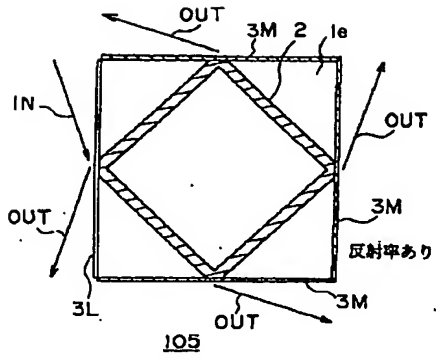

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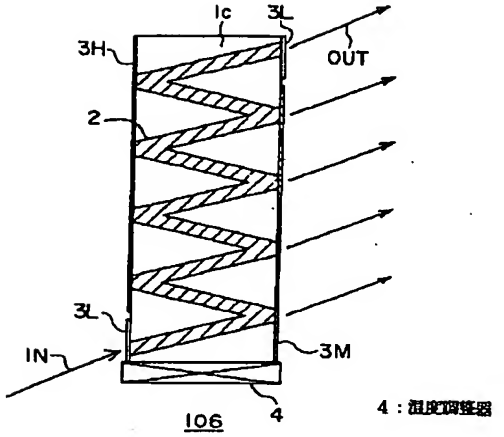
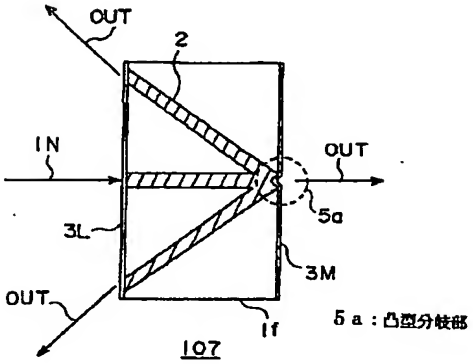


【図7】



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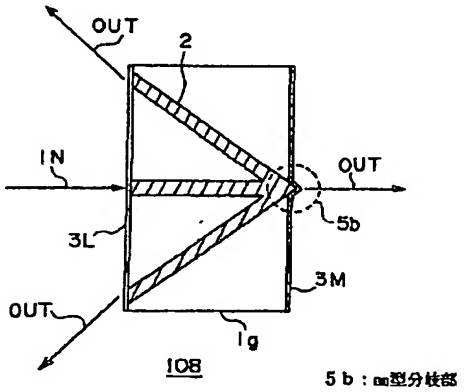

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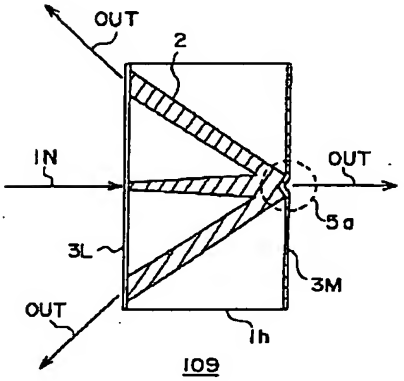
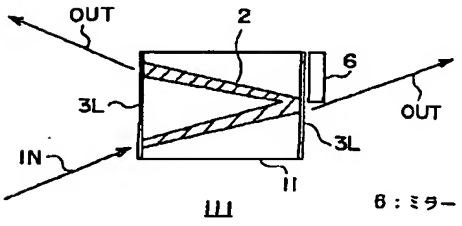
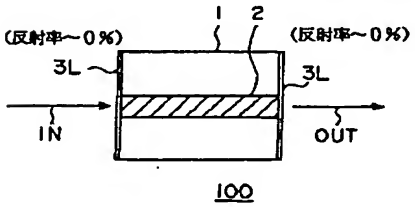


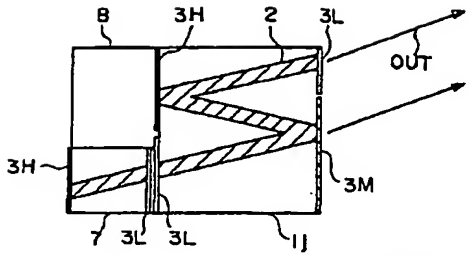
【図11】



【図20】



【図１２】



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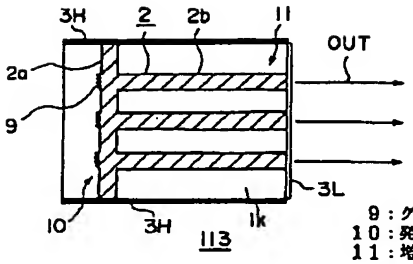
7：半導体レーザ素子
8：基盤

【図１４】



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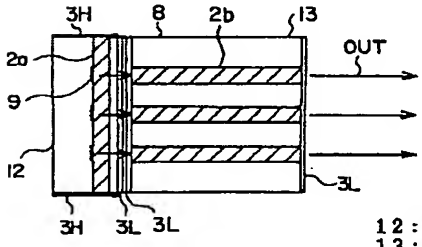
9：グレーディング
10：発振部
11：増幅部

【図１５】



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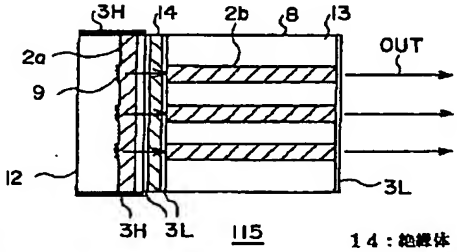
12：発振素子
13：増幅素子

【図１６】



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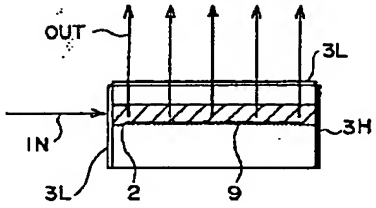
14：絶縁体

【図１７】



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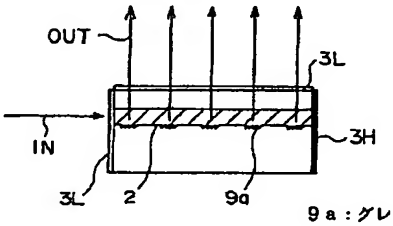
【図１８】



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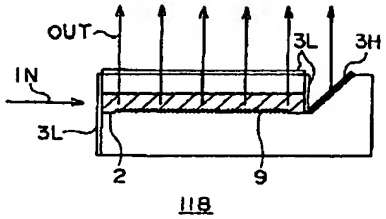
9a：グレーディング

【図１９】



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